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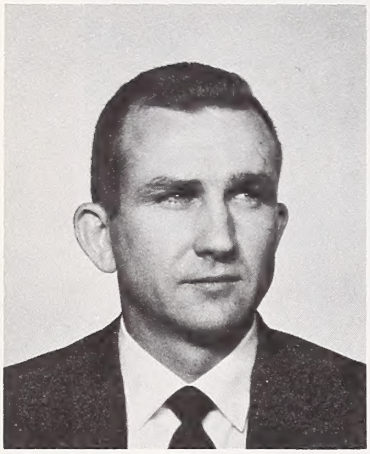

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Growth and Yield of a Thinned Shortleaf Pine Plantation

by

Robert D. Williams

Seven-year results from a stocking study in a shortleaf pine plantation in southern Indiana provide some guidelines for thinning such plantations. From the silvicultural standpoint there was little advantage in thinning when the plantation was only 14 years old. In fact, it appears that shortleaf plantations on similar sites in the Central States should be left unthinned until they are at least 20 years old.

THE STUDY

During the winter of 1950-51 a stocking study was established in a 14-year-old shortleaf pine plantation on the Hoosier National Forest. The plantation is located on a broad ridge that is considered an average site for shortleaf pine in Indiana. The stand was planted on a 6- by 6-foot spacing. Before thinning, the stand averaged 127 square feet of basal area per acre: There were 976 trees per acre averaging 4.9 inches in diameter at breast height (fig. 1).

Sixteen 1/10-acre plots were established. Four were thinned to 80 square feet of basal area per acre (heavy thinning), four to 100 square feet (medium thinning), four to 120 square feet (light thinning), and four were left unthinned as checks. In February 1958, after seven growing seasons, the thinned plots were cut again to the same basal areas (table 1). After the second thinning the heavily thinned plots contained only one-third as many trees as the check plots and less than half as much basal area (figs. 2 and 3).

Table 1.--Stocking per acre, before and after each thinning, by thinning intensity

14-YEAR-OLD STAND

Thinning intensity	Trees		Average Diameter		Basal area	
	Before	After	Before	After	Before	After
	Number	Number	Inches	Inches	Sq. ft.	Sq. ft
Heavy	938	558	5.0	5.2	128	78
Medium	965	740	4.8	5.0	125	100
Light	1,053	863	4.8	5.1	133	119
Check	950	950	4.9	4.9	124	124

21-YEAR-OLD STAND

Heavy	530	312	6.5	6.8	123	80
Medium	718	462	6.0	6.2	145	100
Light	807	543	6.1	6.3	171	120
Check	902	902	5.8	5.8	176	176

Figure 1.--(Right) The 14-year-old stand before thinning contained 127 square feet of basal area and a total volume of 1,435 cubic feet per acre.

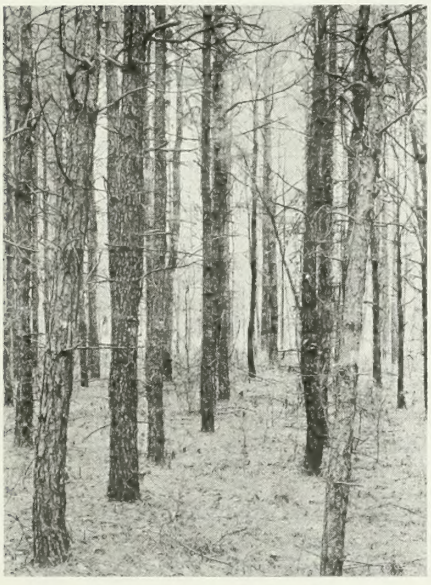
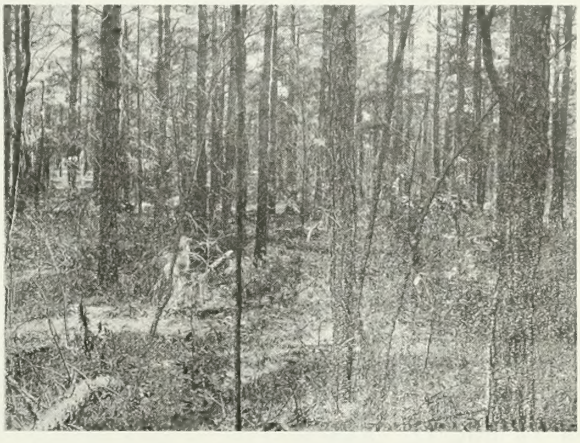


Figure 2.--(Left) Unthinned plot at 21 years. There are 176 square feet of basal area and a total volume of 2,840 cubic feet per acre. Average spacing is 7 by 7 feet.

Figure 3.--(Right) Heavily thinned plot at 21 years. After the second thinning the stand contains 80 square feet of basal area and a total volume of 1,340 cubic feet per acre. Average spacing is 12 by 12 feet.



RESULTS AND DISCUSSION

Thinning at 14 years did not produce encouraging results. Diameter growth per tree increased but (1) height growth was apparently not affected, (2) basal area growth per acre decreased slightly, (3) volume growth and yield per acre decreased, (4) Fomes annosus, a root rot, became established and caused mortality, and (5) the number of large volunteer hardwoods increased.

Diameter and Height Growth

Average diameter growth of all trees for the 7-year period ranged from 1.4 inches on the heavily thinned plots to 1.3 inch on the unthinned plots (table 1). According to statistical analysis, this difference in growth was highly significant[1/], but much of the difference was because there were more small, slow-growing trees on the unthinned plots.

Foresters and plantation owners are primarily concerned with the growth of crop trees so growth of the larger trees on each plot was compared. Stand density had little effect on the growth of 100 crop trees per acre. Average diameter increment of the 100 largest trees per acre was 1.9 inches on the heavily thinned plots and 1.6 inches on the unthinned plots. This difference was not statistically significant.

There was no apparent difference in height growth due to thinning intensity. Mean annual height growth of the average-sized tree remained nearly constant for the life of the stand. The average tree was 25 feet tall at 14 years and 37 feet tall at 21 years. The continued good height growth after 14 years had a favorable effect on volume growth.

1/ Highly significant - 1 chance in 100 the difference is due to chance. Significant - 5 chances in 100 the difference is due to chance.

Basal Area Growth

Basal area growth for the 7-year period was better on the unthinned plots than on the heavily thinned plots (table 1). Before the study began the plots to be thinned had grown slightly faster than the check plots. But after thinning average annual basal area growth per acre was 6.4 square feet on the medium and heavily thinned plots, and 7.4 square feet on the lightly thinned and unthinned plots, a difference of 7 square feet for the 7-year period (fig. 4). This difference, however, was not statistically significant. Mortality caused by Fomes annosus, was responsible for a loss of 2.2 square feet of basal area growth on the heavily thinned plots during the sixth and seventh years after thinning.

Although it is generally accepted that basal area is added to fewer selected trees in thinned stands, the basal area growth on 100 crop trees per acre was about the same on unthinned as on thinned plots.

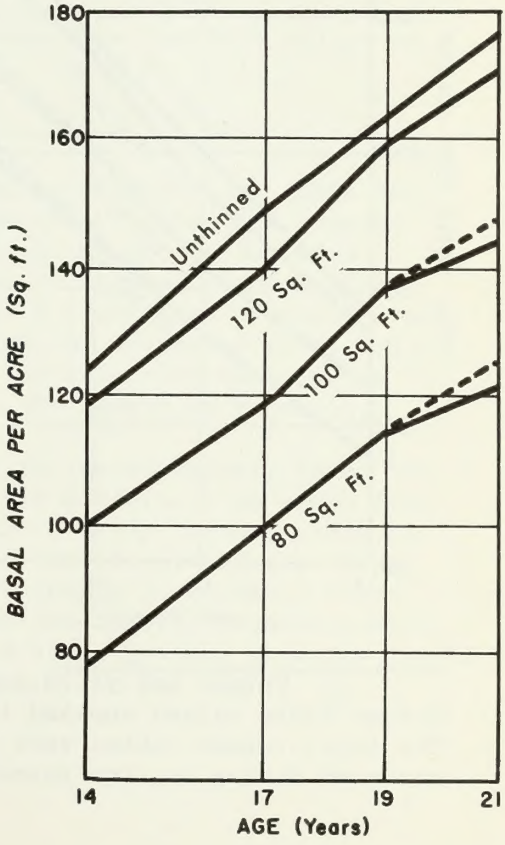


Figure 4.--
Basal area by thinning intensity and stand age. (Basal area loss, due primarily to Fomes annosus, is shown by the dotted lines.)

Volume Growth and Yield[2/]

Seven years' growth made a big difference in the form and volume of the entire stand. Form improved and residual volume of all thinned and unthinned plots more than doubled.

Total cubic-foot volume growth for the 7-year period after thinning was greatest on the unthinned plots and least on the heavily thinned plots. Volume growth ranged from 1,425 cubic feet per acre on the unthinned plots to 1,109 cubic feet on the heavily thinned plots (table 2). This difference was statistically significant. On the heavily thinned plots, Fomes annosus caused a volume loss of 33 cubic feet per acre after the fifth year. Volume on the unthinned plots increased faster and at a more uniform rate than on thinned plots during the 7-year period (fig. 5).

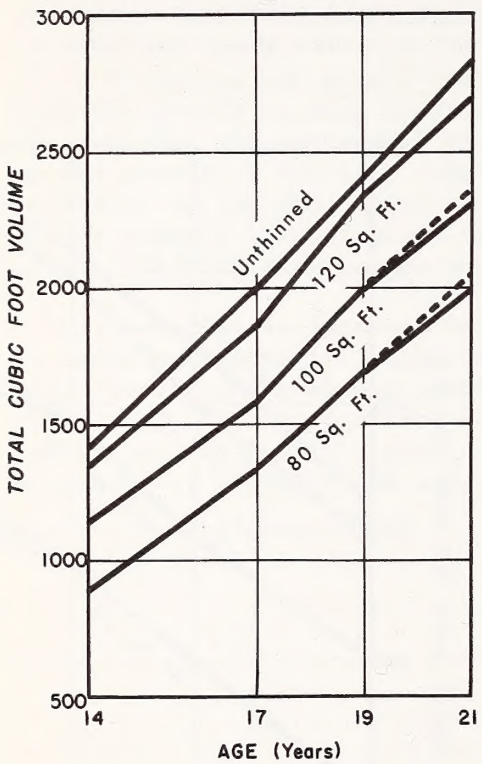


Figure 5.--
Total cubic-foot volume by thinning intensity and age. (Volume loss, due primarily to Fomes annosus, is shown by the dotted lines.)

2/ Volume and yield comparisons are based on local volume table values applied to the 1951 and 1958 stand tables. The local volume tables were constructed from cut-tree data recorded during the two thinnings.

Table 2.--Total volume[1] per acre by thinning intensity

(In cubic feet)

Development		Thinning intensity			
		Heavy	Medium	Light	Check
14-year-old stand	Before cut	1,421	1,448	1,455	1,415
	Cut	523	308	109	--
	After cut	898	1,140	1,346	1,415
	Growth	1,109	1,187	1,355	1,425
21-year-old stand	Before cut	2,007	2,327	2,701	2,840
	Cut	693	704	792	--
	After cut	1,314	1,623	1,909	2,840
Total yield[2]		2,530	2,635	2,810	2,840

1/ Total stem volume inside bark, including stump and top.

2/ Volume from two thinnings plus residual volume at 21 years.

In 7 years the unthinned plots produced 391 cubic feet per acre more merchantable volume than the heavily thinned plots (table 3). Average annual volume growth per acre ranged from 2.2 cords on the heavily thinned plots to 2.9 cords on the unthinned plots. In 7 years this difference was about 5 cords per acre in favor of the unthinned plots. It is still too early to determine the effect of thinning on board-foot volume production and the length of rotation.

Volume growth of all plots increased rapidly after the fourteenth year, so there was a big difference in yield from the two thinnings. Yield from the heavily thinned plots in 1958 was 1.4 times the volume cut in 1951 (table 3). From medium thinned plots the second thinning yield was 3 times greater than the first. And from the lightly thinned plots the second thinning yield was 7.2 times greater than the first.

Table 3.--Merchantable volume[1] per acre by thinning intensity
(In cubic feet)

Development		Thinning intensity			
		Heavy	Medium	Light	Check
14-year-old stand	Before cut	1,106	1,056	1,108	1,015
	Cut	425	206	97	--
	After cut	681	850	1,011	1,015
	Growth	1,156	1,239	1,421	1,547
21-year-old stand	Before cut	1,837	2,089	2,432	2,562
	Cut	616	618	698	--
	After cut	1,221	1,471	1,734	2,562
Total yield[2]					
Cubic feet		2,262	2,295	2,529	2,562
Cords[3]		30.2	30.6	33.7	34.2

1/ Volume to a 3-inch top inside bark, excluding stump.

2/ Volume from two thinnings, plus residual volume at 21 years.

3/ Standard cords found by dividing merchantable cubic foot volume by 75 (2).

Merchantable volume on the heavily thinned plots, after the 1958 cut, was greater than volume before the first thinning. And on the unthinned plots merchantable volume in 1958 was 2.5 times the volume in 1951. Similarly, in a southern Illinois study, Boggess and McMillan (1)[3] found that yields from comparable plantations thinned at different ages were quite varied when row thinning was used. Yield from thinning an 18-year-old stand was more than double the yield from thinning a 14-year-old stand. And the residual volume of the 18-year-old stand was greater than the volume of the 14-year-old stand before thinning.

3/ Numbers in parenthesis refer to literature cited, page 12.

Mortality

Mortality for the 7-year period was negligible on some plots and severe on others. There was poor correlation between number of dead trees and residual stocking, but more trees died on the lightly thinned and unthinned plots. The number of dead trees per acre by thinning intensity, for the 7-year period was as follows: heavy thinning, 28; medium thinning, 22; light thinning, 56; and no thinning, 48.

Fomes annosus, a root rot found in thinned pine plantations throughout the eastern United States (3), was responsible for most of the mortality on the medium and heavily thinned plots. Trees in all size classes died on these plots. F. annosus was not detected on the lightly thinned or unthinned plots. On these plots only small, overtopped trees died.

Volume loss was greatest on the thinned plots because Fomes annosus killed larger trees (fig. 6). However, the merchantable volume loss per acre caused by this disease was only 27 cubic feet on the heavily thinned plots. Mortality caused by Fomes annosus was not apparent until the sixth year after thinning. Few pine plantations in southern Indiana have been thinned, so it is not possible to say how widespread Fomes annosus may become. It is too early to predict what effect this disease may have on the management of pine plantations.

Figure 6.-- An infection center of Fomes annosus on a heavily thinned plot. The tree in the middle foreground and the six trees represented by the high stumps marked with an "X" died in this infection center.

Hardwood Invasion

Hardwoods are invading this plantation. The greatest single influence on hardwood invasion is proximity of seed trees. More and larger hardwoods are found near the edges of plantations. So far, stand density has had little effect on the number of hardwoods (table 4) but the larger hardwoods are more numerous on the heavily thinned plots (fig. 7). Sassafras and persimmon are predominant on the more open plots and a few elm and redbud make up the bulk of the basal area on the check plots.

The desirable invading species in order of occurrence are ash, black cherry, sweetgum, yellow-poplar, and red, white, and black oaks. Some of the more numerous poor species are sassafras, persimmon, elms, redbud, dogwood, sumac, and red and sugar maples.

Table 4.--Volunteer hardwoods per acre by thinning intensity, 1958

Thinning intensity	Hardwoods 0.6 inch d.b.h. and larger		All hardwoods on transects			
	Stems	Basal area	Total	Av. ht.	Desirability of species	
					Good	Poor
	Number	Sq. ft.	Number	Feet	Number	Number
Heavy	502	6.4	2,675	3.7	950	1,725
Medium	475	5.9	2,725	5.2	1,200	1,525
Light	277	2.7	2,775	2.7	1,225	1,550
Check	280	6.4	2,725	3.7	1,100	1,625

Figure 7.-- The larger invading hardwoods are more numerous on the heavily thinned plots. Sassafras and persimmon are predominant.

SUMMARY AND CONCLUSIONS

In 1951 a stocking density study was established in a 14-year-old shortleaf pine plantation in southern Indiana. Twelve plots were thinned to three different densities of basal area per acre: 80 square feet, 100 square feet, and 120 square feet. Four plots were left unthinned as checks. In 1958 the thinned plots were thinned again to the same residual basal areas.

Diameter growth was greatest on plots thinned to 80 square feet, but basal area growth was slightly greater on unthinned plots. However, there was little difference in diameter or basal area growth of 100 crop trees per acre, regardless of thinning intensity. Neither was there any apparent difference in height growth due to thinning intensity.

Volume growth was best on the unthinned plots. In the seven years after thinning, these plots produced 5 cords more wood per acre than the heavily thinned plots. Therefore, if thinning is delayed beyond 14 years, better tree form and accelerated volume growth will result in a bigger cut. Also, products cut will be more valuable.

Fomes annosus, a root rot, occurred in the medium and heavily thinned plots the sixth growing season after thinning. If F. annosus becomes widespread and no control is found, future plantings may have to be made on a wider spacing to make early thinning unnecessary. The importance of this disease needs evaluation.

Hardwoods were invading all plots, regardless of thinning intensity. But larger trees were more numerous near the edges of the plantation and on heavily thinned plots. Heavy thinning in young stands may stimulate severe hardwood competition long before the pine is ready for the harvest cut.

From this study it appears that, if shortleaf pine plantations on similar sites are left unthinned until at least 20 years old, more and better products may be expected. Optimum age for the first thinning may be even greater than 20 years. Future remeasurements will provide this information.

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